Virtual Personal Service Assistants: Towards Real-time Characters with Artificial Hearts

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ABSTRACT

Over the last years there has been a growing consensus that new generation interfaces turn their focus on the human element by enriching an *Affective* dimension. Affective generation of autonomous agent behaviour aspires to give computer interfaces emotional states that relate and take into account user as well as system environment considerations. Internally, through computational models of artificial hearts (emotion and personality), and externally through believable multi-modal expression augmented with quasi-human characteristics. Computational models of affect are addressing problems of how agents arrive at a given affective state. Much of this work is targeting the entertainment environment and generally does not address the requirements of multi-agent systems, where behaviour is dynamically changing based on agent goals as well as the shared data and knowledge. This paper discusses one of the requirements for real-time realisation of Personal Service Assistant interface characters.

We describe an approach to enabling the computational perception required for the automated generation of affective behaviour in multi-agent real-time environments. This uses a current agent communication language so as they not only convey the semantic content of knowledge exchange but also they can communicate affective attitudes about the shared knowledge.

Keywords

Personal Service Assistants; Interface Agents; Affective Communication; Multi-agent Systems.

INTRODUCTION

Current work in the Agent and Human-Computer Interaction communities have brought together an interface metaphor that acts as a mediator between human and computer, so called, the Personal Service Assistant (PSA). This work shows growing evidence that the PSA metaphor will shape the communication medium of new generation interfaces. Recently, many areas of research have been converging on the important implications of *Affective Computing*: "computing that relates to, arises from or deliberately influences emotions" [29]. As a result, ongoing research on PSAs aims at creating affective, believable anthropomorphic agent embodiments, which has indications that they hold significant promise for substantially increasing the usability of applications [16] due to their affective and strong visual presence. Moreover, research on user attitudes towards computers has shown that most users respond socially to their computers [26]. These results are motivating ongoing research in this area, in that since users anthropomorphise computers anyway, the presence of affective interface agents will be appealing and may have positive implications on system usability and efficiency which can effect the work load as a whole.

Embodying the interface with quasi-human animated characters and endowing them with emotional behaviour and distinct, predefined personality has been the subject of a growing body of research. Among which are: André & Rist [1], Bates [4], Blumberg [5], Lester *et al* [18], Microsoft [19], and Virtual Personalities Inc. [22], and many more. Much of this work is targeting presentation and entertainment fields and, generally does not, so far, address the real-time requirements of multi-agent systems - MAS, where behaviour is dynamically changing based on agent goals as well as the shared data and knowledge. In most of the aforementioned systems, affective behaviour is triggered by intentional, pre-scripted input, leaving little support for the dynamic nature of real-time MAS. Thus, there is need for real-time loosely coupled triggers not tied with any particular action script, theory or model. The challenge of the system we discuss is to generate affective behaviour and control driven by such dynamic data. One such agent system that was developed to deal with dynamic services (information, data media etc – all of which could be interacted with in real-time) using a personal service assistant was the KIMSAC architecture [21, 7,8,10]. Part of the design of this architecture was a meta-representation. Hence, we use the work from Charlton *et al* [8,10] which provides a language for representing meta-level knowledge

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being manipulated between the agents in a MAS conveying the current state.

The following section presents a summary of the features required for real-time PSA characters [9,11,12]. We also relate this to previous work in the area. In section 3 we summarise the use of meta-annotations of manipulated objects and information to enabling the support of affect within inter-agent dialogue. We position the approach within our overall architecture. Finally, we conclude with some discussion on our ongoing work.

PSAs: SHAPING TOMORROW'S INTERFACES

Personal Service Assistants are autonomous Interface Agents that employ intelligence and adaptive reasoning methods to provide active, collaborative services and assistance to users' of a given application [13,20,30]. Interface agents differ from customary interfaces in that they are expected to change behaviour and actions autonomously according to users' actions and the surrounding system environment as an interaction progresses. Because their main role is to engage in communication with users, they are often termed as Conversational Agents. The PSA metaphor aims towards providing effective highly personalised services. Personifying the PSA with a context generated affect-based character is an additional dimension to providing personalised services. The motivation for this type of personalisation is that an animated figure, eliciting quasi-human capabilities, may add an expressive dimension to the PSA's communicative features which can add to the effectiveness and personalisation of the interface and the application on the whole. Since there is strong evidence that Affect has major influence on learning and recall [6,12], reasoning and decision making [16], both collectively effecting system usability and efficiency, and in turn, effecting the overall work load.

The Role of a PSA

The KIMSAC system was one of the first implementations to support the general roles of PSA [7,12,13]. Their role is to act as mediators between the human and the computer cyberspace and to be capable of personalising an interface by monitoring and sensing individuals' capabilities, interests, and preferences [13,17,30]. As such, PSA functionality is realised on two levels [13]: the service level and the interface level. The PSA is, hence, considered a service agent[1] that must communicate and negotiate with other agents in a multi-agent system to determine which and how services are to be provided. As all software agents are distinguishably characterised by the services they provide, the PSA is principally characterised as a user-oriented agent. It is expected to facilitate and provide mechanisms that enhance an application's efficiency and usability from both interface and functionality perspectives. The PSA may take on different functional roles like Sales or Advertiser agents in e-commerce [31]; Helper or Personal Assistant agents in different application domains [8, 22], Presenter [1]; as Pedagogical or Training agents [18, 28] or many more.

[1] A specialised agent dedicated to provide a particular service.

ENABLING THE DYNAMICS OF A PSA

In a multi-agent environment the PSA inhabits a world which is dynamic and unpredictable. To be autonomous, it must be able to perceive its environment and decide its actions to reach the goals defined by its behavioural models. To visually represent the behaviour, the relevant actions and behaviour must be transformed into visual motional actions. Therefore the design of an animated behavioural PSA system requires components to endow them with perception, behaviour processing and generation, action selection, and behaviour interpretation into believable graphical representation.

Perception through Agent Communication

In order for the PSA to select the appropriate actions, the behavioural system needs to be aware and able to perceive the state of the surrounding environment. Most agents in multi-agent systems communicate using a communication language. However, to share a rich medium of communication a rich context is required. In order to provide a rich context for communication we build on the work of Charlton *et al* [8, 10, 13], which defined an asset description language for a meta-representation to explicitly provide a rich context with effect.

Inter-agent communication is the means by which conversation is mediated between an agent and the agent society wherein it is situated. We use this communication to acquire the information required for PSAs' affective perception on both the how and what dimensions. We consider the development of PSA perception as a process of two well-defined, separate stages:

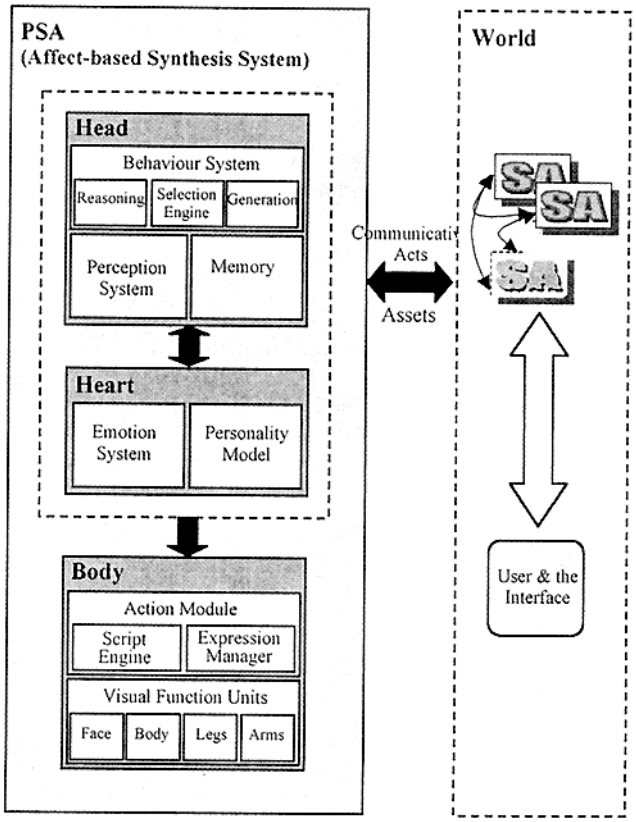
- Inter-agent interaction between the various entities within a MAS society (see [7,13,14,15,23] for more details). We further consider three levels of inter-agent communication at which affect may be conveyed:
  - **content level**: referring to the actual raw message or object intended to be communicated among the entities;
  - **intentional level**; expressing the intentions of agents' communicative acts, usually as performatives of an agent communication language; and
  - **conversational level**: protocols that govern the conversations shared between agents when exchanging dialogue,
- PSA logics of Head and Heart: dealing with the agents' inner behaviour (knowledge representation, reasoning, learning, etc.), the agents social and affective behaviour, and the generation of appropriate behaviour states that are transformed into scripts for visual embodiment in the interface.

Although current primitives could be extended to distinctively convey an affective message, the existing

primitives capture many of our intuitions about what constitutes affect from the communicative act irrespective of application. We consider that semantic description could provide a model of affect that is useful for modelling the overall behaviour as illustrated by Charlton [13].

Positioning within the Overall Architecture

We have discussed input to the perception module from an agents' communication language point of view. We now briefly explain how affect is modelled within the overall architecture. The system is composed of three modules: the Head, which deals with perception, continuous memory, reasoning, and behaviour selection and generation; the Heart, which maintains and manipulates the affect models of emotion and personality; and the body, which deals with behaviour action execution and visual representation. The



system architecture is delineated in *figure 1*.

Figure 1 - **System Overview**

The perception system provides the state of the world to the behavioural and emotional modules through agent communication and Asset descriptions. When Assets are fed into the perception system it is unwrapped to extract the initial indicators and feed into the behaviour system. The behaviour system then uses this information, along with information of past experiences and memory to select the appropriate behavioural response. The resulting behaviour is fed into the action module to generate the appropriate script for animated visual representation.

We use emotion to describe short-term variations in internal mental states, describing focused meaning pertaining to specific incidences or situations. The emotional model is based on the description of emotions made by Ortony *et. al.* [27]. We view emotion as brief short termed, and focused with respect to a particular matter. We assume that a character need not exhibit all the attributes of the emotion or personality definition to be a successful affect model. It needs to incorporate at least some of the more basic features of affect.

We use personality to characterise patterns of emotion, and behaviour associated with the synthetic character. Personality is the general behaviour characteristics that do not arise from and are not pertaining to any particular matter. We model the broad qualities that include individually distinctive, and consistently enduring yet subject to influence and change. Psychologists have characterised five basic dimensions of personality, so known as, the Five Factor model or Big Five [24] of independent traits.

CONCLUSION

The paper discussed work in progress for further enabling PSA characters in a real-time multi-agent environment. We see the need for an operational approach to enabling the computational perception required for the automated generation of affective behaviour through inter-agent communication in multi-agent real-time environments. In an effort to address this need, we have used the framework provided by Charlton *et al* [7,8,10] on meta-level knowledge representation, of affective relations, which are annotations of objects being manipulated between agents in a multi-agent system that can convey the current state.

This work on affect-based systems builds on and extends a current implementation of a PSA in the KIMSAC system in (Kiosk-based Integrated Multimedia Service Access for Citizens - supported by EU's ACTS 030 programme). The framework is to be implemented and used by two European projects MAPPA (Multimedia Access through Personal Persistent Agents – ESPRIT EP28831) . For more details about our approach see Arafa *et al* [2,3].

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